NCDOT Hydraulics Unit Standard Workflows for Ditch Design Using OpenRoads Designer

ORD 2021 R1 (v. 10.10.01.03)

November 29, 2021

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I.   General Workflow

This document is intended to be used for design of drainage ditches that are outside the limits of the roadway slope stake lines. "Cut ditches" within the limits of the roadway footprint will be part of the roadway corridor model. Hydraulics Unit staff will continue to design these ditches and provide the ditch alignment and profile data to the Roadway Design staff for incorporation into the roadway corridor models. For ditches outside the roadway corridor models, Hydraulics Unit staff will use OpenRoads Designer tools for layout and design. The following general workflow has been developed for that purpose, as detailed in the remainder of this document.

A. Complete initial layout of channels using OpenRoads tools to establish an initial corridor model for the ditch that incorporates civil "rule" dependencies to terrains, geometry, and/or roadway corridors as desired. Some preliminary hydraulic capacity/stability assessment should be performed beforehand to identify approximate ditch dimensions and minimum and maximum ditch slope constraints for the ditch profile.

B. Using the initial ditch layout, including the dimensions and profiles for the ditch reach segments, use FlowMaster, FHWA Toolbox, a spreadsheet, or some other means to perform a hydraulic analysis to check capacity and velocity and determine the required ditch cross-section and lining needed for each reach. If the OpenRoads Drainage and Utility channel layout tools are used for hydraulic analysis of ditches, refer to separate documentation for those tools.

C. Make adjustments of the OpenRoads ditch design based on the hydraulic assessment. Using the proposed cross-section data and lining types for each reach, add parametric constraints and adjust template drop selections for the ditch corridor model to update the design. If needed, the profile can also be adjusted. Repeat Steps B and C if needed until ditch corridor model is finalized.

D. After the ditch corridor model is finalized, use OpenRoads civil tools to obtain baseline station, baseline offset, and ditch invert elevation for construction layout and plan/profile annotation. Identify and prepare the ditch cross section details that will be required for plan production. Provide to Roadway Design staff the name and location of DGN files containing the ditch corridor models. The Roadway Design staff may elect to use the ditch corridor models for reference into roadway cross sections, or instead incorporate the ditch design data directly into the Roadway corridor models.

## II. Layout of Head and Tail Ditches

Head and tail ditches have independent alignments – they are not part of, or dependent upon, a roadway corridor model. Head and tail ditches typically flow towards or away from a drainage system element such as an inlet, headwall, end section, or open-ended pipe. However, the following procedures can be used for any ditch with an independent alignment outside the grading limits of a roadway corridor. Ditches should be created in a new DGN file created from a 2D seed.

A. As detailed below, the general workflow includes the following steps:

1. Create horizontal alignment.

2. Create vertical alignment and make it the Active Profile for the horizontal alignment.

3. Create a corridor model by applying one of the standard NCDOT ditch templates for head/tail ditches.

4. Make adjustments as needed to the ditch corridor model by adjusting the horizontal and/or vertical alignments, or adding/modifying template drops, parametric constraints, and/or point controls.
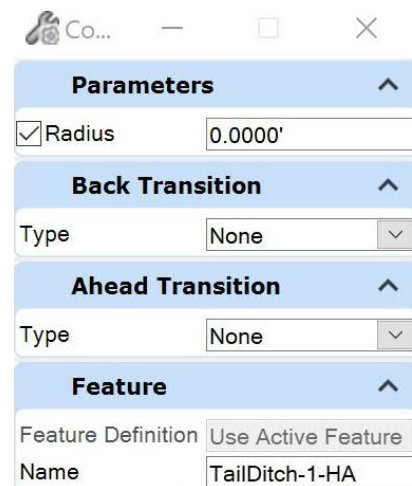
B. Create ditch horizontal alignment.

1. Make sure the workflow is set to OpenRoads Modeling.

2. Go to *Geometry > Standards > Feature Definition Toolbar* and dock it above the view window if not already there. Set the active feature definition to *Linear > HYD_Ditch > HYD_TL_Ditch_Middle*, and toggle on Use Active Feature Definition.
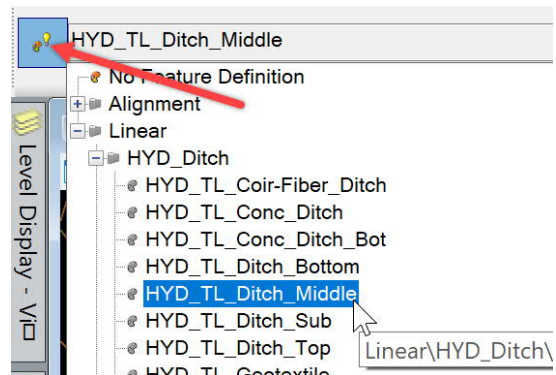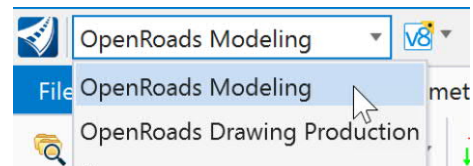
3. Go to *Geometry > Horizontal* and select Complex by PI.

2
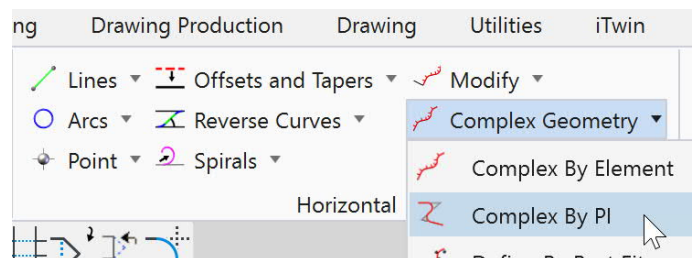
4. In the tool settings dialog or heads up prompt, provide a unique name for the alignment such as TailDitch-1-HA.

5. Set the value for radius to 0.0 and set the Ahead and Back Transitions to None.

6. <D> ("accept" or left mouse click for standard right-hand mouse setup) in the design file to place PI points along the proposed ditch centerline to layout an alignment as shown in the example below.
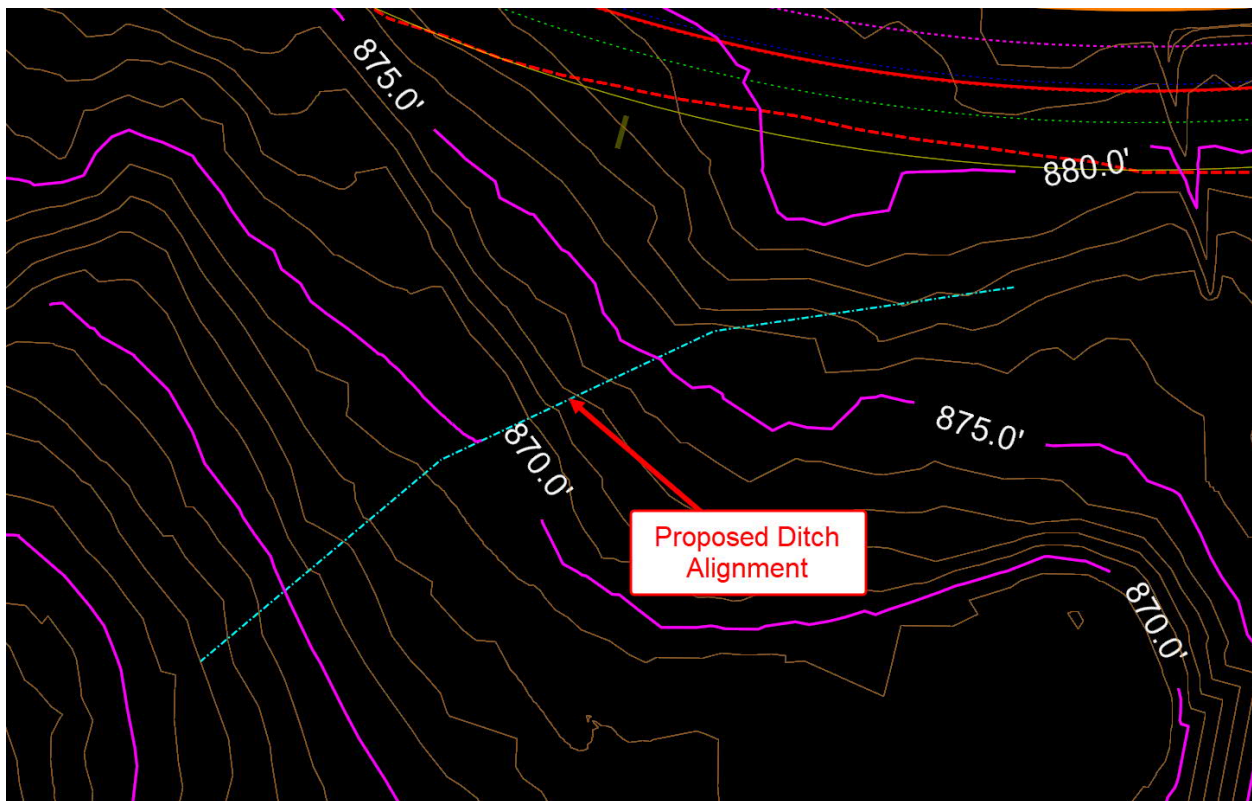
| Parameters	^
☑ Radius	0.0000'
Back Transition	^
Type	None ⌄
Ahead Transition	^
Type	None ⌄
Feature	^
Feature Definition	Use Active Feature
Name	TailDitch-1-HA

Proposed Ditch Alignment

7. After alignment is created, you can revise it by selecting the alignment and clicking and dragging any of the PI points. Go to *Common Tools > Table Editor* and use this tool to add a radius to any PI points that create sharp bends in the alignment that may cause crossing templates in the corridor model (if you're not sure, you can hold off and do this later as needed). However, it is usually desirable to avoid curves in order to simply construction layout.

C. Create ditch invert vertical alignment.

1. Select a feature from the referenced existing terrain and from the fly-out menu select Set As Active Terrain Model.

2. Use the Element Selection tool to select the ditch horizontal alignment, and from fly-out menu, select Open Profile Model. Select an unused view window and <D> in the window to create a profile model.

3. Click on the View Attributes in the upper left corner of the profile model view window. Under the Civil tab you can change the profile exaggeration if desired.

4. Go to *Geometry > Vertical > Complex Geometry* and select Profile Complex by PI.
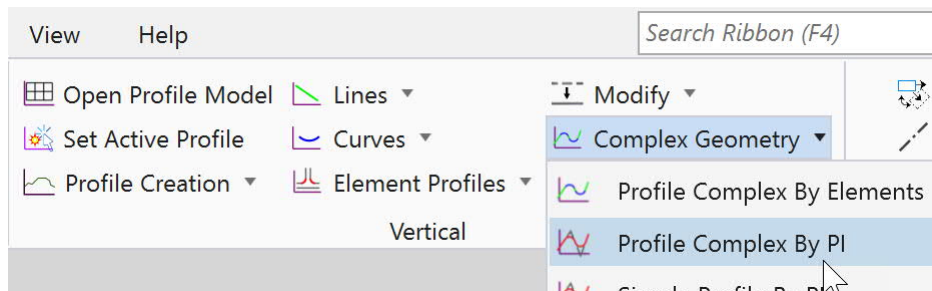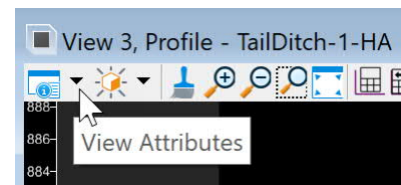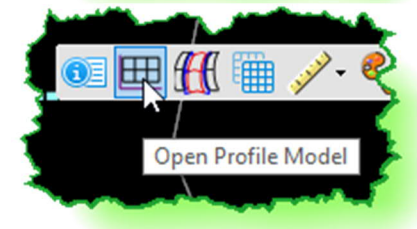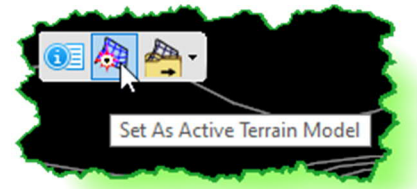
5. Provide a unique Name such as TailDitch-1-VA.

6. Check the box for Curve Length, enter a value of 0.0, and leave the other boxes in the dialog unchecked. Profiles for ditches should not use vertical curves.

7. Set invert elevations at upstream and downstream end of the ditch, as well as any intermediate points by placing data points in the profile window to create a series of PI points as shown on the next page. However, read Steps 8 through 11 below before placing your vertical PI points.
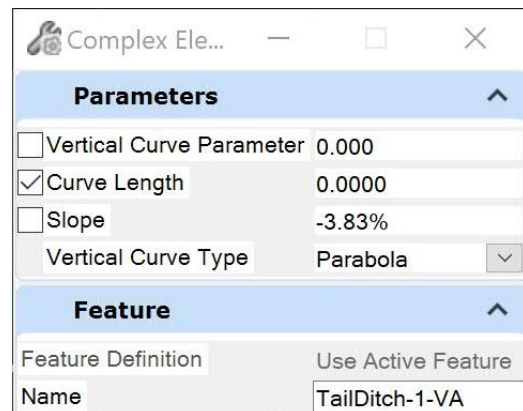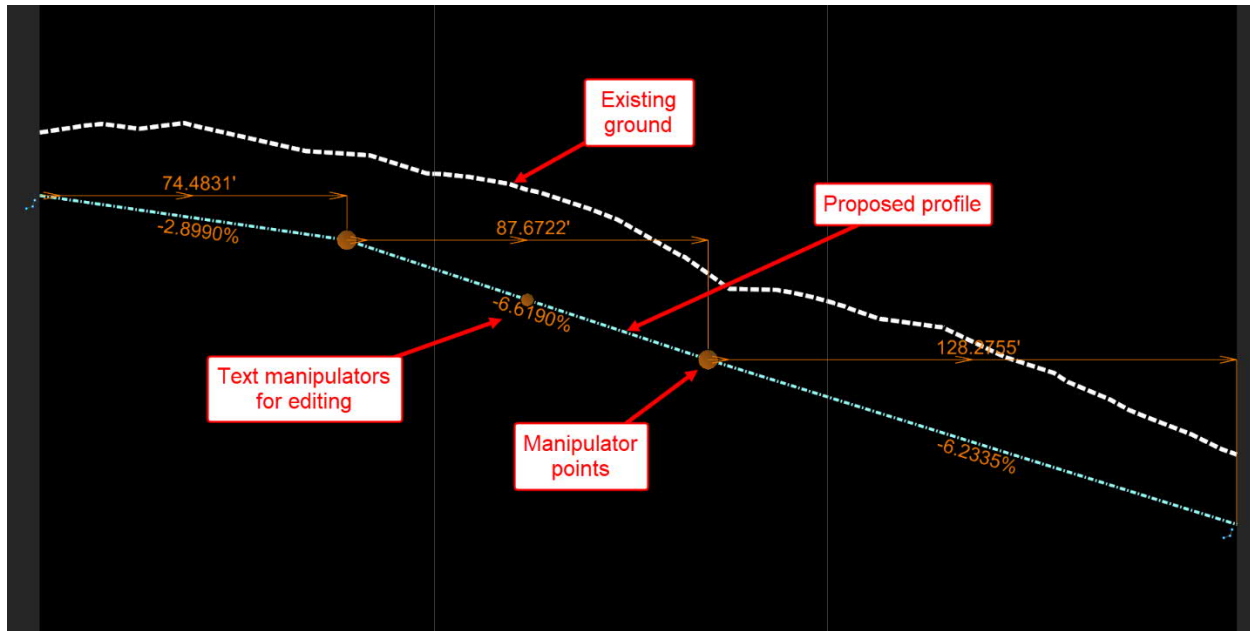
8. Remember that when placing the PI points, you can use Civil Accudraw to specify a slope, a particular station and/or elevation, or a vertical offset. If you don't have this toolbar docked, go to *Geometry > Civil Toggles > Civil Accudraw* and open the toolbar and dock it.

Set to Station-Offset Mode
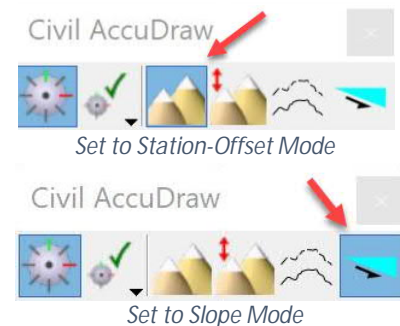
9. When done, <R> ("reset" or right mouse click for standard right-hand mouse setup) to complete the process.

Set to Slope Mode

10. After alignment is created, you can revise it by selecting the alignment and clicking and dragging any of the PI points. Remember you can use the Undo tool at any time. You can also edit the profile using the text manipulators for station and elevation of the PI points, as well as the slope of the lines. You can also use the Microstation Add Vertex and Delete Vertex tools to add PI points.

11. In some situations, you may want to snap to existing ground at the start or end of a profile to tie into the existing surface. Or you may want to snap the vertical PI points to the vertical gray lines in order to make the vertical PI points coincide with the horizontal PI points (which is recommended). However, remember that when you use a snap, you are creating a civil rule.

Do you want to prevent your ditch profile from automatically updating if the terrain model is revised? Do you want to be able to revise the vertical PI points after they have been snapped to the horizontal PI locations? If so, then you do _not_ want to

create these civil rules. If you ever want to snap to an element without creating a civil rule dependency, toggle off the Persist Snaps and Rule toggle on the Feature Definition Toolbar. It is recommended that you do this when creating ditch profiles.


12. When the profile is done, select it and from the flyout menu select Set As Active Profile. The alignment will now appear in the 3D model view if you have it open. Note: any time after the ditch corridor has been created, you can come back to this profile model window and revise the profile and the corridor will automatically reprocess. This is also true of any changes to the horizontal alignment. However, if changes are made to the horizontal alignment, you should check the profile as well to make any needed revisions.

D. Create a corridor model for the ditch.

1. Go to *Corridors > Create > Template* and select Create Template. When the dialog opens, go to *File > Open* and browse to C:\MICROSTATION_CONNECT_WORKSPACE-10.10\Configuration\Organization-Civil\Disciplines\NCDOT_Hydraulics\Standards\Template Library and select NCDOT-Hydraulics-Ditches.ITL, and then click Open. Then close the Create Template dialog.

2. Go to the *Corridors* tab and select New Corridor.

3. In the dialog box, for the Feature Definition go to Corridors and select HYD w/Contours from the drop-down list.

4. At the prompt *Locate Corridor Baseline*, select the previously created horizontal alignment.
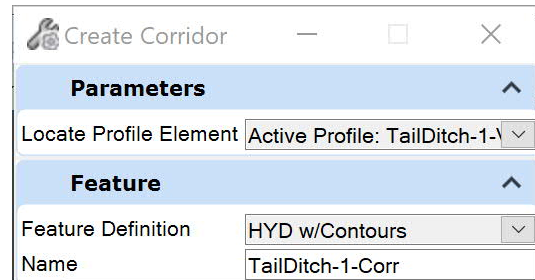
5. At the prompt *Locate Profile*, select the profile previously created that represents the ditch centerline profile. Do not <R> to select the active profile, but select it from the drop-down list in the dialog box. This will ensure that if someone later makes a different profile active, this corridor model will not reprocess and use the newly active profile.

6. At the prompt *Corridor Name*, provide unique name such as TailDitch-1-Corr and <D> to accept. A temporary shape will appear representing the newly-created corridor model (see example on the next page). Move your mouse a little to get the next prompt to select a template drop.

6

Temporary shape
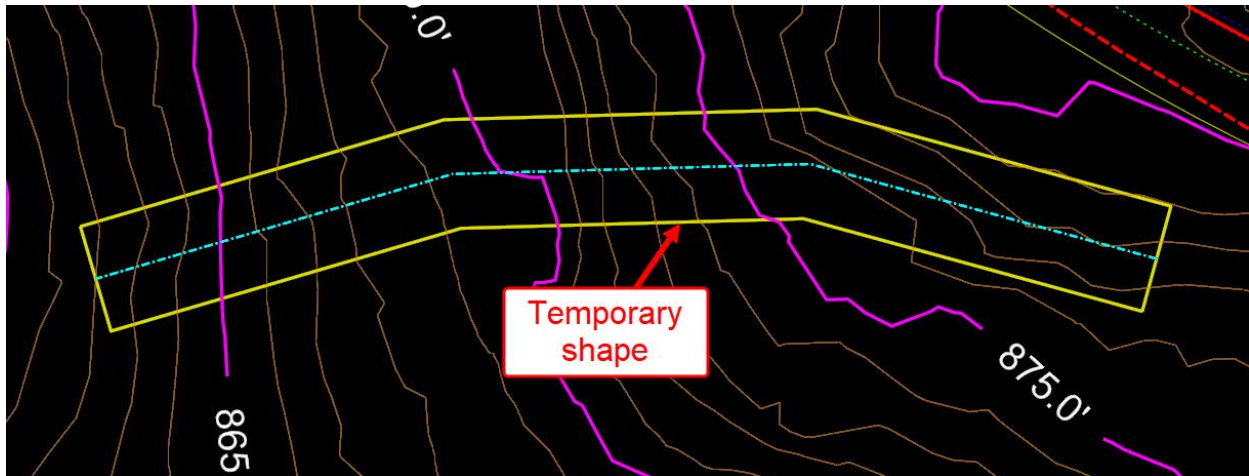
7.   If you accidentally exit from the process at this point, simply select that shape and from the flyout menu select Corridor Creation Tools > Create Template Drop.

8.   In the dialog box, in the Template field, go to *Typical Sections > Drainage Ditches > Head/Tail Ditches* and select the template Trap_Riprap_CL-B. Or, if using the heads up prompt, press ALT + Down Arrow to select the template. Click OK.
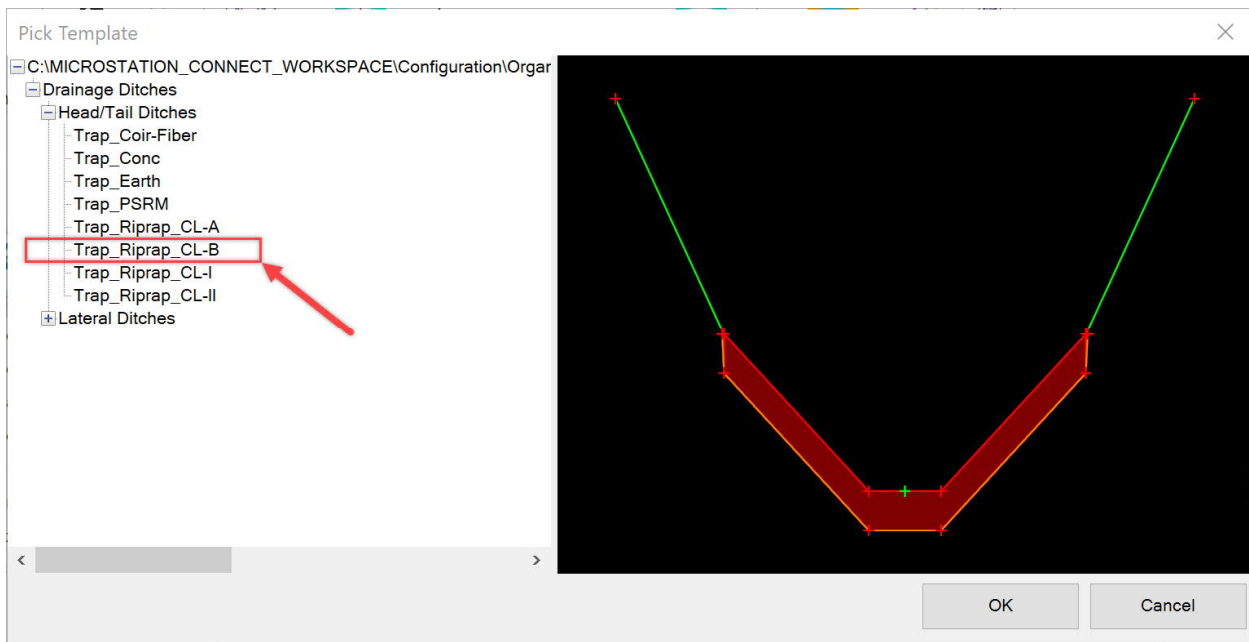

9.   Check the boxes for Lock to Start and Lock to End in the tool settings dialog (or press the ALT key if using the heads up prompts) to apply the template to the entire ditch alignment. Alternatively, you can specify specific start and end locations for the template by keying in station values, or by selecting graphically in the file with your mouse.

10. Check the box for Drop Interval and enter a reasonable value such as 5.0 (or enter directly by using the heads up prompt).

11. <D> in the design file to accept all dialog settings. After confirming the Drop Interval, the corridor model will be created and displayed in the view window.

12. Go to *Home > Primary > Attach Tools > References* and turn off display of the referenced 3D model.
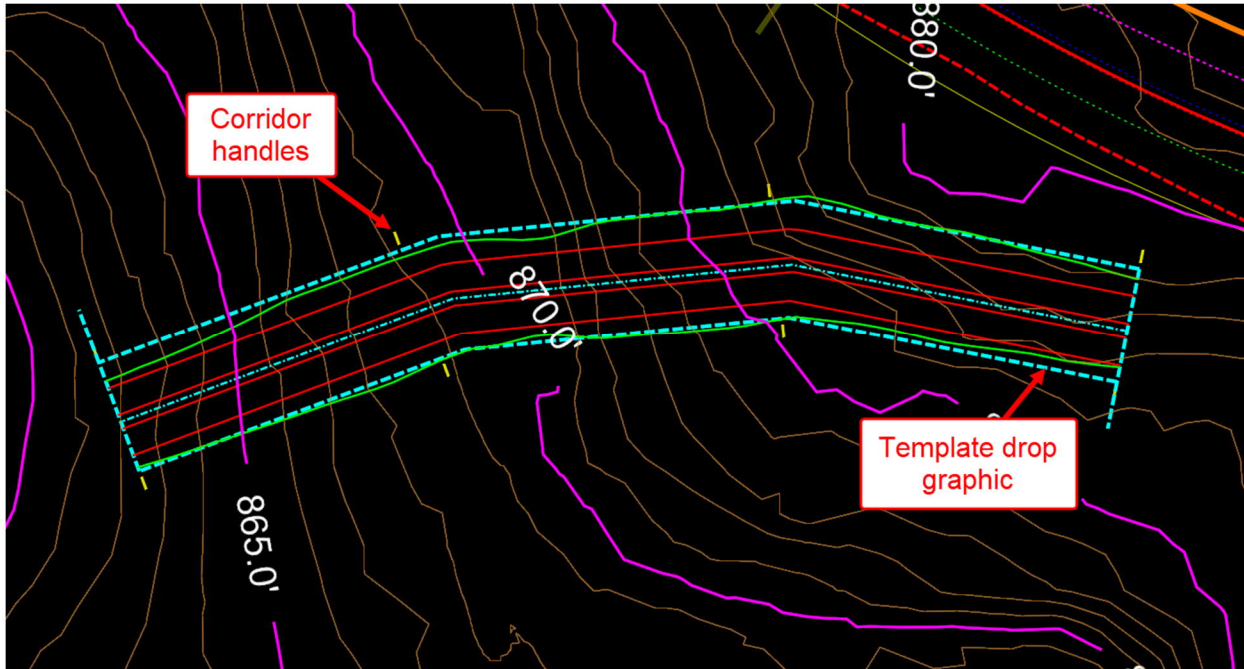

13. Note the graphics that are displayed:

- Lines for Top of cut slope/limit of grading (green).

- Line for ditch center (light blue dashed line) and bottom width of ditch (red).

- Lines for limits of the riprap lining (red).

- Graphics for the corridor handles (yellow) and template drops (dashed light blue). To edit a ditch corridor, you select these graphics and choose reviewing and editing tools from the flyout menu. If desired, you can turn off display of these graphics which are on the level Draft_Corridor_Graphics_Final.

- Note: the corridor graphics and the ditch centerline have an Element Class set to Construction, so they will not plot.

14. Turn on display of the referenced 3D model and go to *Home > Primary > Level Display*, select the 3D model reference, and turn off display for all levels except P_HYD_Contour_Major and P_HYD_Contour_Major.
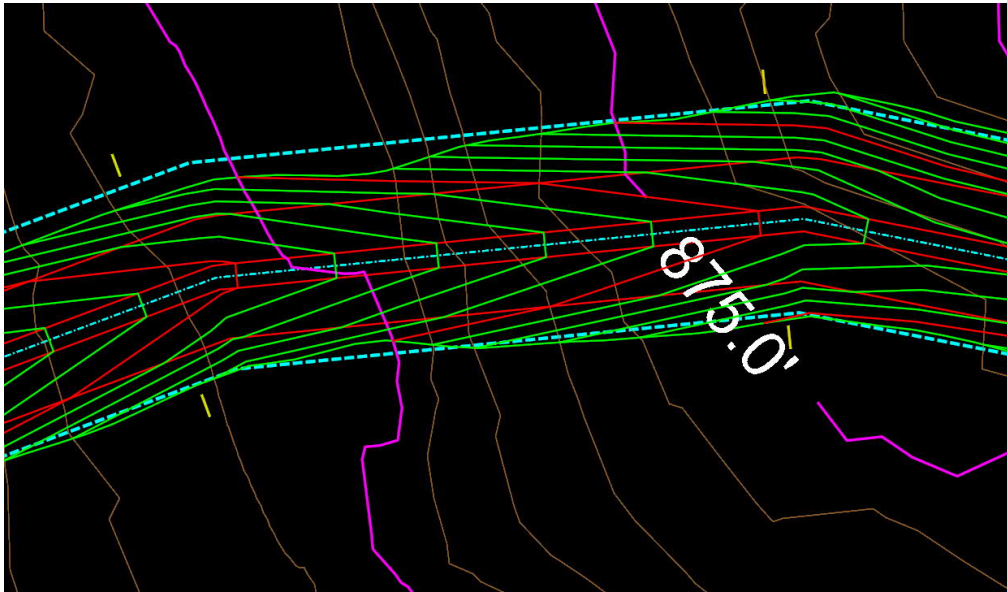
Notice that the displayed contours reflect the 4:1 slope of the riprap lining and the 2:1 slope of the ditch slopes beyond the riprap. As discussed in Section IV of this document, these slopes (as well as other ditch dimensions and channel lining) can be revised as desired after the corridor model has been created.

E. Using Dynamic Sections to Review the Corridor Model

1. Go to *Corridors > Review > Dynamic Sections > Open Cross Section View*. At the prompt *Locate Corridor or Alignment*, select the manipulator handle for the corridor in the plan view window. Or you can select one of the corridor handles and select this tool from the flyout menu.

2. Select an unused view window and <D> in the window to display a cross-section view of the corridor. Note that the riprap lining and fabric layers are displayed, as well as the existing ground and nearby roadway corridor model. Anything that is referenced to the 3D model will be visible here such as proposed drainage and existing or proposed utilities.
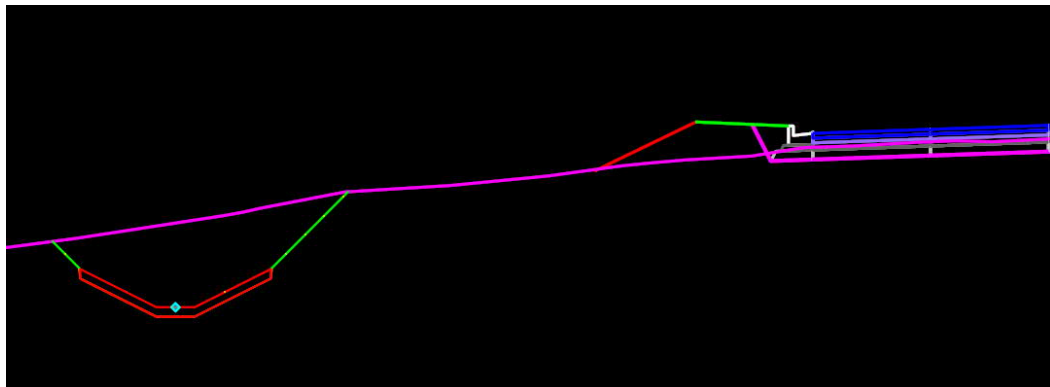
If the road corridor or existing terrain is not shown, make sure the cross section window is active and then go to Level Display and check that the level display for these reference files is turned on.

You can use the left and right arrow navigation buttons to step through the corridor cross-sections. However, this can be very tedious. There are better ways to navigate the cross section viewer:

1. Click on the station drop-down list and directly enter a station value. However, be sure your mouse cursor stays in the key-in field when you press ENTER or it will often not work.

2. <R> and press in the cross section view window to display the tool menu. About 2/3 the way down the list select Locate Station Via Datapoint. You will then be prompted to pick a plan or profile view window (note that you can use either) and then <D> to identify the station visually, snap to identify the station from a graphic element, or key-in a specific station.

3. Once a cross section view has been established for a corridor, select one of the corridor handles, and a "slider" handle will appear. Drag this slider up and down the corridor to quickly review cross sections. See image below.

Cross section view slider handle
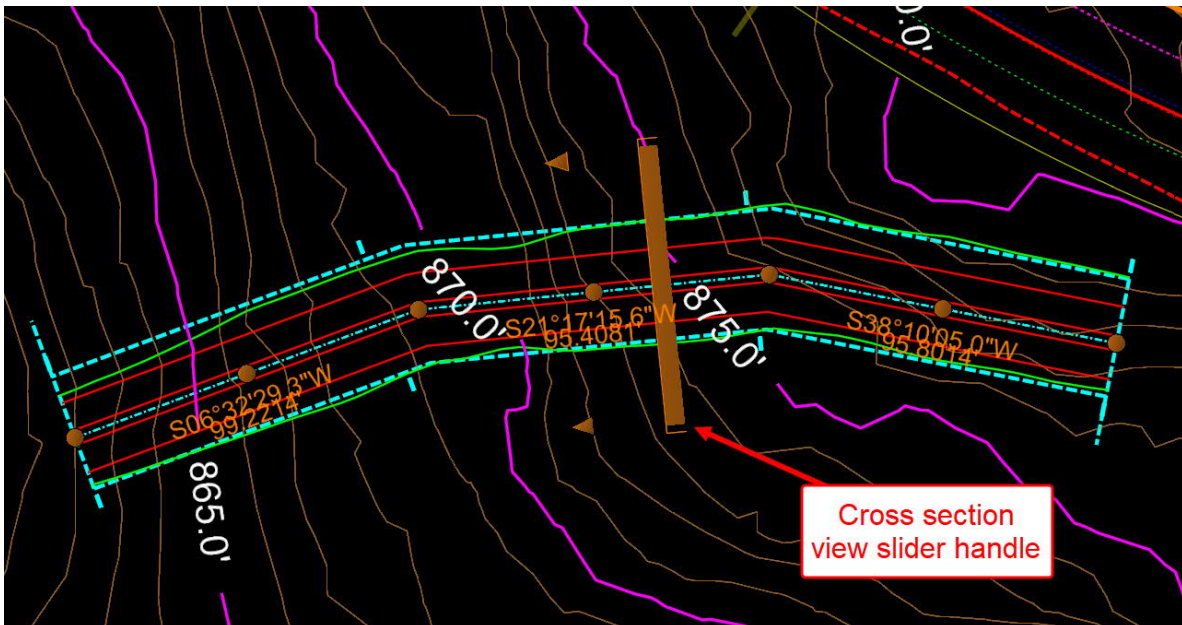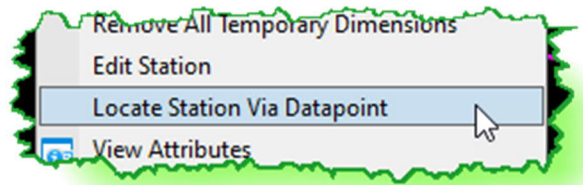
F. Using the 3D Model to Review the Corridor Model

1. Select and open the view window for the 3D model. If one has not been set up yet,
    then <R> and press in a view window and go to *View Control > 2 Views Plan/3D* to
    have OpenRoads create a 3D model view.
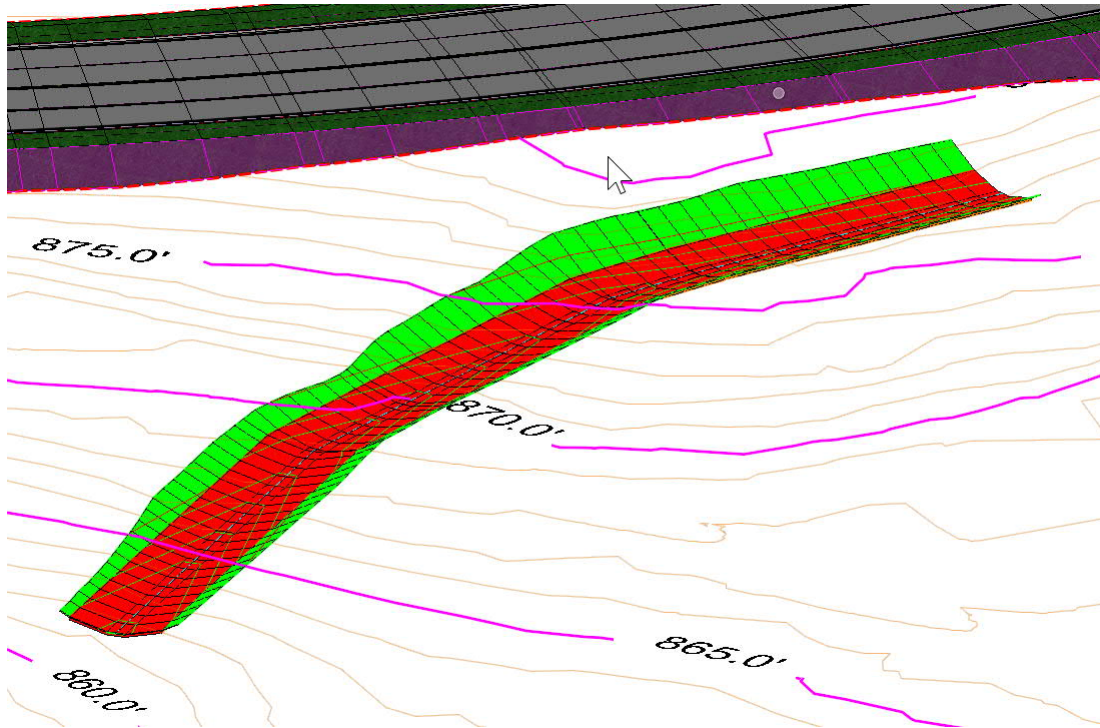
2. Select Fit View and zoom to the area of interest. Use Rotate View with Method set
    to Dynamic to provide a 3D perspective view. Be sure to move the cross-hair so that
    it snaps to an element near your area of interest before rotating.

3. Go to *Home > Primary > Level Display* and verify that the levels
    P_HYD_Contour_Major and P_HYD_Contour_Major for contour display are turned
    on.

III. Layout of Special Lateral Ditches

Lateral ditches are located next to the toe of a fill slope (slope stake line) for a roadway. Using OpenRoads, such ditches can be dynamically tied to the slope stake line such that shifts of the slope stake line automatically result in a corresponding shift in the ditch location. To accomplish this, a template with an origin point on the left or right side will be needed. Such templates are available in the NCDOT WorkSpace. Ditches should be created in a new DGN file created from a 2D seed, and DGN files containing the existing terrain model and roadway corridor model should be referenced.

A. As detailed below, the general workflow includes the following steps:

1. Use the slope stake line feature from the roadway corridor model (attached as a reference file) to create a ditch corridor model using the desired ditch template. The location of the ditch centerline and the profile of the ditch will initially be based on the default template dimensions.

2. Create an independent profile for the ditch using corridor point controls.

3. Make adjustments as needed to the ditch corridor model:

    • Adjustments to the vertical alignment.

    • Add or modify parametric constraints to change ditch dimensions such as bottom width, foreslope and backslope, lining depth and thickness, bench width, etc.

   • Add or modify template drops to specify ditch lining.

B. Create initial corridor model for ditch.

1. Select a feature from the referenced existing terrain model and set it as the Active Terrain as discussed in the previous section.

2. Turn on display of the referenced CMD corridor model and ALG geometry files.

3. As discussed in the previous section, in the OpenRoads Modeling workflow, go to *Corridors > Create > Template* and select Create Template. When the dialog opens, go to *File > Open* and browse to C:\MICROSTATION_CONNECT_WORKSPACE-10.10\Configuration\Organization-Civil\Disciplines\NCDOT_Hydraulics\Standards\Template Library and select NCDOT-Hydraulics-Ditches.ITL, and then click Open. Then close the Create Template dialog.

4. Go to *Corridors > Create* and select New Corridor.

5. In the dialog box, go to Feature Definition and select HYD w/Contours from the drop-down list.
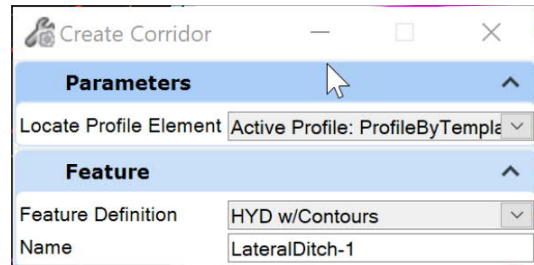
6. At the prompt *Locate Corridor Baseline*, select the toe of slope line feature from the roadway corridor model. Be sure to hover over the feature first and use the ORD attribute feedback to verify you are selecting the correct feature. <R> if needed to cycle through other features that may be located in the same place.

7. At the prompt *Locate Profile*, <R> to select the active profile for the toe of slope line feature.

8. At the prompt *Corridor Name*, provide unique name such as LateralDitch-1 in the dialog and <D> to accept and then move your mouse a little to bring up the Create Template Drop dialog shown below.
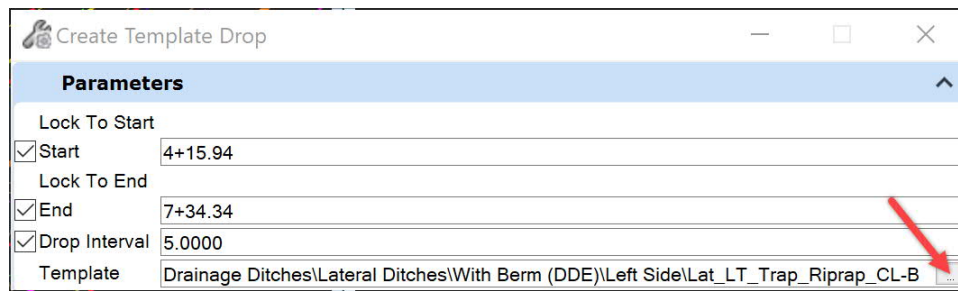
To select a template, you can either click on the ellipsis button in the dialog or use the ALT + Down Arrow key combination on your keyboard to open the Pick Template window.
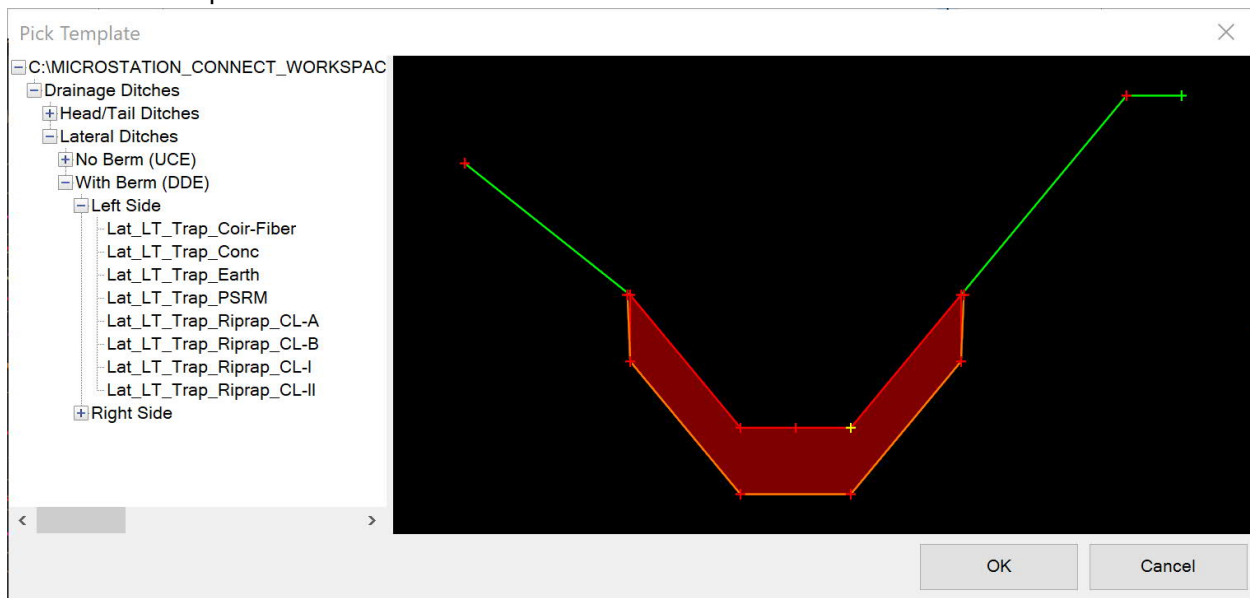
Note that the Lateral Ditches folder contains two subfolders:

- No Berm (UCE). Use these templates to model ditches where the ditch foreslope is a continuation of the roadway fill slope, with no berm (Unclassified Excavation quantity).
- With Berm (DDE). Use these templates to model ditches where the ditch foreslope is different than the fill slope (Drainage Ditch Excavation quantity). Typically, such ditches will also have a berm between the slope stake line and the top of the ditch foreslope, but you can choose to change the berm width value to zero if desired by using a Parametric Constraint, as explained later in this document.

Note also that the above two folders are further divided for ditches that are located on the Left and Right side of the roadway. In accordance with the standard convention, "left" and "right" are defined as looking up-station in reference to the roadway baseline. It is important that you select a template for the correct side.

9. In the current example, browse to *Drainage Ditches > Lateral Ditches > With Berm > Left Side* and select Lat_LT_Trap_Riprap_CL-B for a base ditch with Class B riprap.

10. Specify the Start and Stop station by using your mouse or entering values. Remember that the ditch needs to be stationed <u>in the same direction as the roadway baseline</u>, which may be the opposite direction of the ditch flow.

11. Enter a value for Drop Interval such as 5.0.

12. <D> in the design file to accept all dialog settings. The corridor model will be created and displayed in the plan view window.
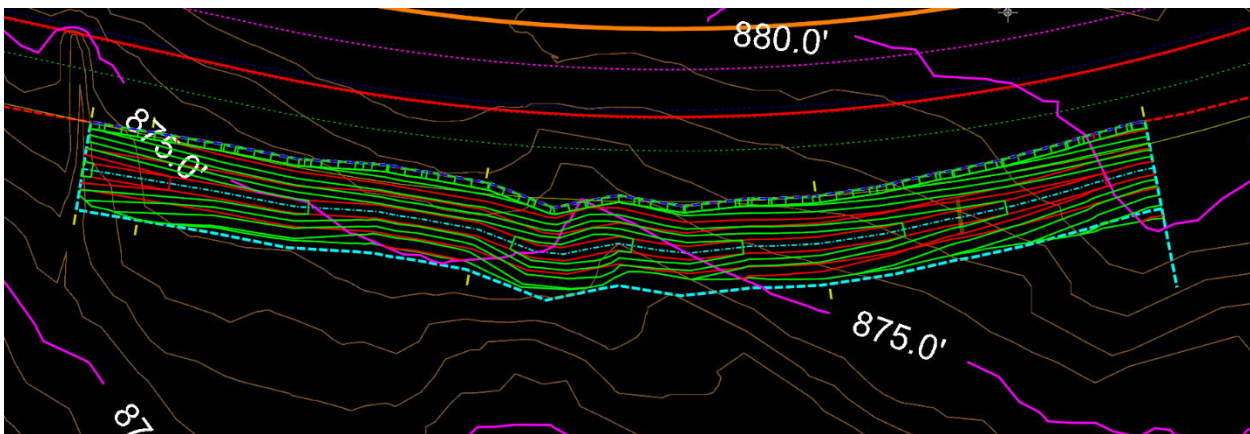

Note that in this example the ditch has a low point in it because it is following the profile of the slope stake line. This will be addressed in the following steps.

13. As discussed in the previous section, go to *Primary > References* and turn on display for the 3D model to see the contour lines for the new ditch corridor.

14. As discussed in the previous section, create a dynamic cross section view window to review the corridor.

C. At this point the ditch has a uniform depth such that the ditch bottom is a fixed distance below the toe of the fill slope. We now need to add Point Controls to establish an independent profile for the ditch.

1. As explained in the previous section, select the ditch centerline feature in the new ditch corridor and from the fly-out menu select Open Profile Model, select an unused view window and <D> in the window to view the profile. The existing ground profile and the initial ditch invert profile will be displayed.
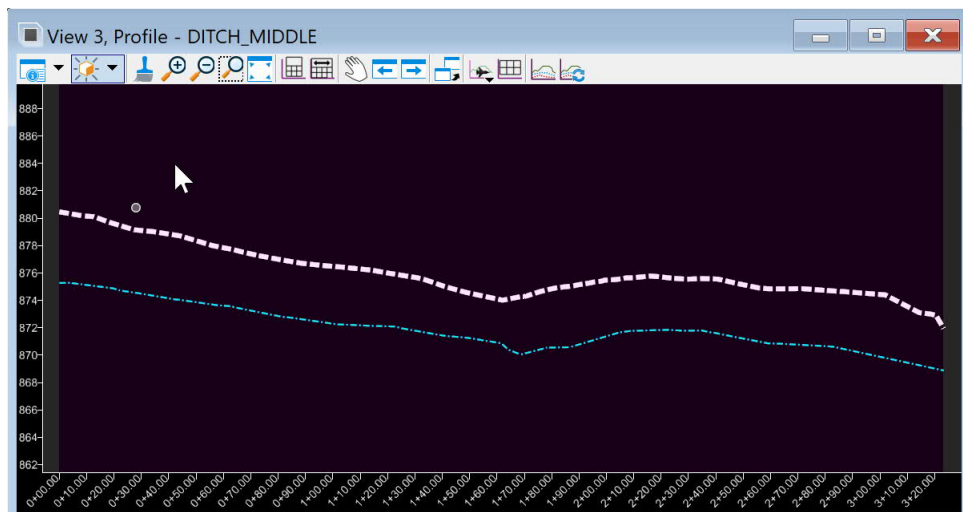
2. To create the Point Controls for the ditch profile adjustments, you will need a table of start and stop stations, start elevations, and slopes. To develop this data, it is helpful at this point to create a temporary profile in the profile model window to layout your proposed profile points. As explained in the previous section, use the Feature Definition Toolbar to set the default Feature Definition to HYD_TL_Ditch_Middle.

3. Go to *Geometry > Vertical > Complex Geometry > Profile Complex by PI* and use the procedure detailed in the previous section to create a profile from PI points. Do not worry about being precise for the first try. You can always make adjustments later. Ensure that the box for Curve Length is checked and the value is set to zero. Create a meaningful name such as LateralDitch-1-VA. Don't forget about Civil Accudraw.
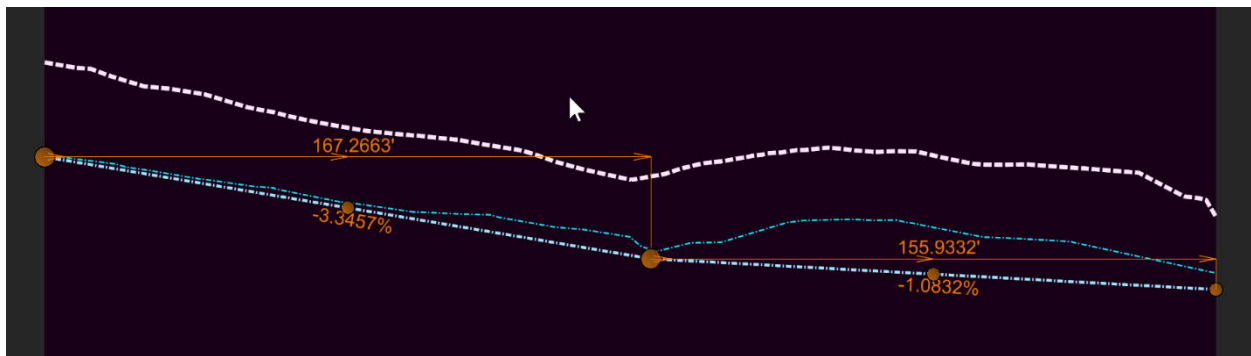

Remember that we used the slope stake line from the roadway corridor model as the horizontal control for our ditch corridor. Therefore, the stationing for the ditch corridor is taken from the slope stake line. Therefore, unless you started your ditch corridor at the very beginning of the slope stake line, the stationing for the ditch centerline (from which you created the profile) is not the same as the ditch corridor stationing. You need to account for this when creating your table of data for the Point Controls. The station data for the Point Controls must match the <u>corridor</u> stationing, not the ditch centerline stationing.

4. Go to *Home > Model Analysis and Reporting > Civil Analysis > Analyze Point*, select the slope stake line in the <u>plan view</u>, and then in the profile view you can obtain the corridor stationing for each of the profile PI points you created.

5. The data shown below is an example; your data will be different.

	Ditch Station	Start Elevation	Slope
Start	415.94	875.27	-3.3457%
PI	582.95	869.67	-1.0832%
End	734.34		

6. Select one of the ditch corridor handles and from the flyout menu go to Corridor Creation Tools and select Create Point Control.
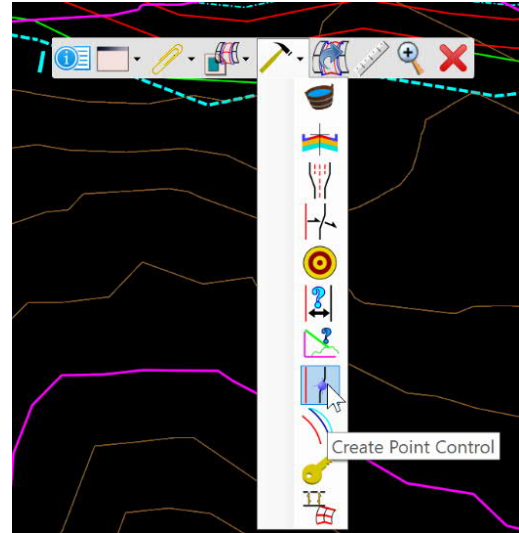
7. In the dialog for Create Point Control (see next page), check the boxes for Start and Stop and enter the first set of stations from the data table: 415.94 and 582.95.

8. For Control Description, enter DitchInvert.

9. From the drop down list for Point, select PROF_CTRL. This is the bottom of the ditch foreslope – and the point in the template that is to be controlled by the Point Control. This is the point you must always choose, regardless of which ditch template was selected for the corridor.

10. Select Vertical for the Mode, and Elevation and Grade for the Control Type.

11. Enter 875.27 for the elevation and -3.3457% from the data table.

12. <D> in the design file to accept all prompts. The corridor will reprocess, and you will see the ditch profile update. Note that the new profile will not exactly match your temporary profile because the stationing of the corridor is based on the alignment of the toe of the roadway fill slope, not the alignment of the ditch centerline, and it's the ditch centerline that was used for the profile.

13. Redo this process to add a second point control using Start = 582.95, Stop = 734.34, Elevation = 869.67, and Slope = -1.0832%. Continue adding point controls to the corridor until all data has been entered.

14. In the profile window, delete the temporary profile. As a result of crossing template drops in the corridor model, you may see "bumpiness" in the profile. Addressing this issue is discussed later in this document.
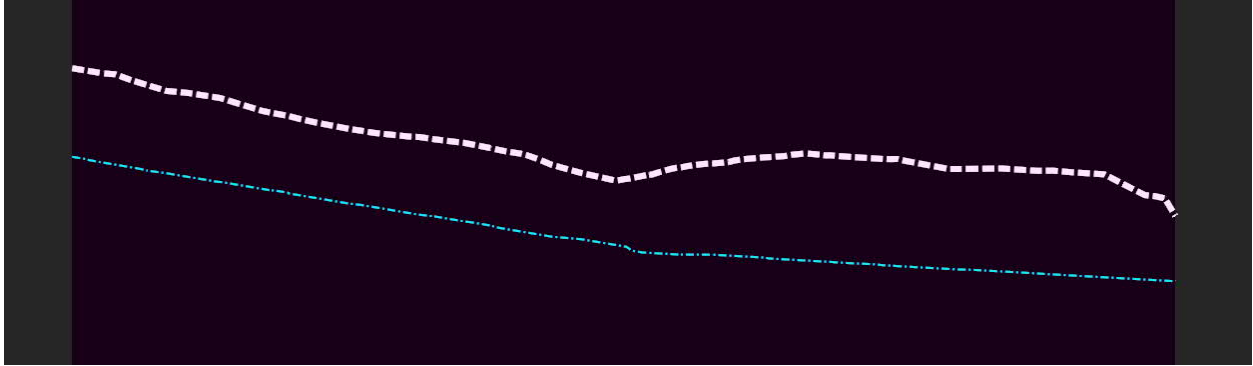

15. Turn on display of the referenced 3D model and review the contour grading for the ditch. Notice that the low point in the ditch has been eliminated.
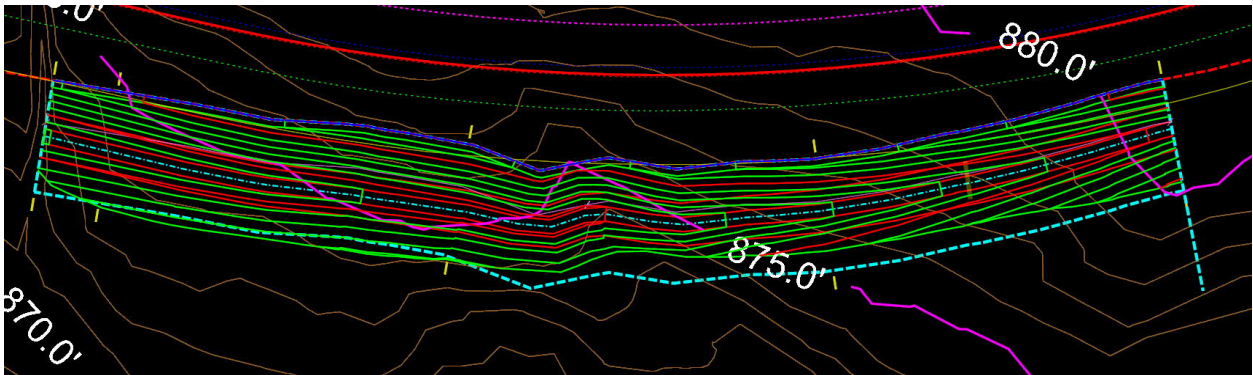
16. Go to the 3D model view window and review the ditch, using the Rotate View tool.
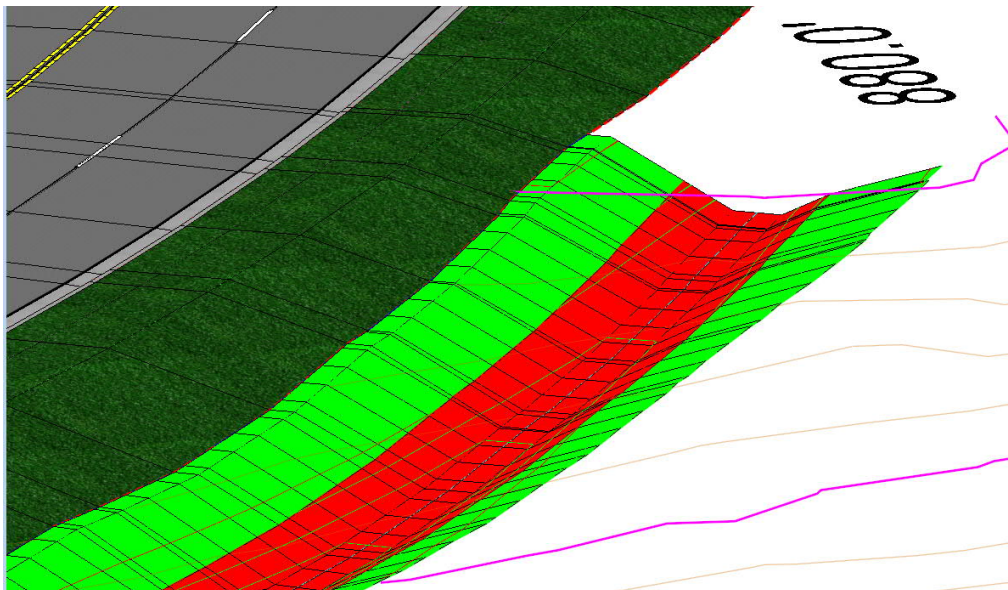
This approach works best when the fill slope toe is linear and does not have abrupt angular changes in horizontal alignment. Deflection angles in horizontal alignment may create template drops that cross each other and cause model glitches. Usually, moderate changes in alignment are tolerated fairly well when contours are displayed. As you can see in the example below, there is an area where templates are crossing. Yet, the contour display was acceptable.
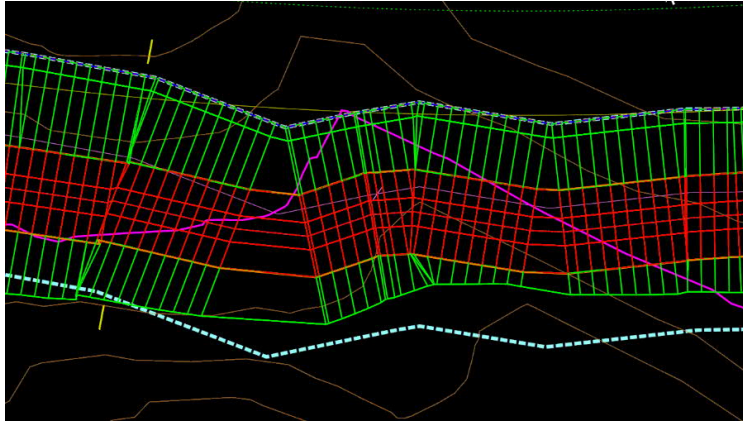
If crossing templates become a problem, there are two approaches you can take to address the issue:
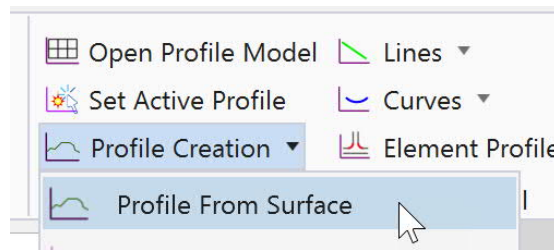
1. The easiest approach is to simply reduce the frequency of template drops by increasing the template drop interval. Select the graphic for the template drop (light blue dashed line) and from the flyout menu select Properties. In the Quick
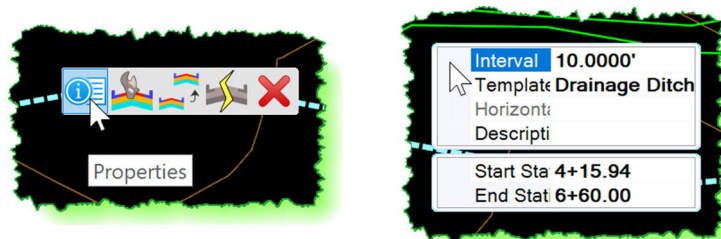
Properties dialog that pops up, type in a new (larger) value for the Interval. This is typically an iterative process – try various values until you obtain the desired results. Usually, continuing to increase the Interval beyond a certain value will not be helpful, so increase the Interval in small steps. If you cannot obtain acceptable results using this approach, then try the second approach below.

2. Use the approach for head and tail ditches detailed in Section II of this document. Instead of using the roadway corridor slope stake line as the ditch corridor horizontal control, place a separate alignment along the path of the slope stake line. Then, using the Table Editor at *Geometry > Common Tools*, add a curve to the horizontal alignment at the problem location to prevent the crossing template drops. Some things to remember when using this approach:

- Once the horizontal alignment has been set, you will need to establish a profile for the control line which is based on draping the alignment on the existing terrain. To do this, go to *Geometry > Vertical > Profile Creation > Profile From Surface*. Follow the prompts or complete the dialog to create a profile and don't forget to set it as the "active" profile when finished.

- Try using smaller radius values. You can usually eliminate the crossing template drops with small curves in the alignment.

- Remember that when creating the horizontal alignment, you can snap to the slope stake line wherever you wish to create a "ruled" alignment that will update if the roadway slope stake line shifts.

Berm Ditches

For modeling purposes, berm ditches can be considered a type of lateral ditch and you can use the same templates in the ditch template library for this purpose. The difference is that instead of using the slope stake line at the bottom of a fill slope as your control, you use the slope stake line at the top of a cut slope as your control. Alternatively, you can create a separate alignment as an offset from the top of the cut slope, and give it its own profile by draping it over the existing ground using Profile From Surface as described previously.

IV.   Adjusting the Ditch Design
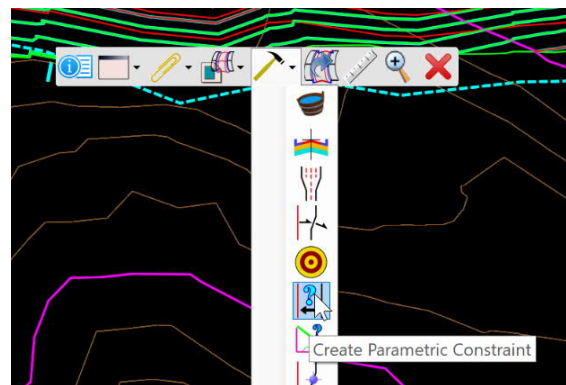
A. Adding Parametric Constraints

At this point, the roadside ditch corridor has been created utilizing default values for the bench offset from the slope toe, ditch bottom width, left and right-side slope, height of channel lining, and thickness of channel lining and bedding layers. These default values were taken from the specific template that was selected during the corridor creation process. The next step in the process is to adjust the corridor model based on the hydraulic assessment that was completed.

The NCDOT standard templates for ditches contain "parametric constraints". Parametric constraints allow for template variables, such as bottom width or side slope, to be defined in reference to a parameter that can be varied in the corridor model. In this way, the ditch dimensions can be adjusted at various locations along the corridor without having to re-create the corridor or create new templates.
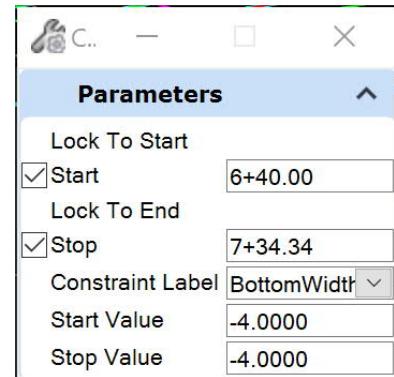
Before revising the ditch dimensions, you should first finalize the previously created ditch invert vertical alignment if needed by revising the Point Controls. The corridor will automatically re-process. If the vertical alignment is revised, then review the previous hydraulic analysis and determine if ditch dimensions or linings need to be revised as a result.

In this example, parametric constraints will be used to widen the ditch below station 6+40. A transition section will be added between 6+20 and 6+40. Therefore, two parametric constraints will be needed: one for the widened ditch and one for the widening transition. Remember, however, that the stationing used for the parametric constraints will use the ditch corridor stationing, not the ditch centerline stationing, nor the roadway baseline stationing.
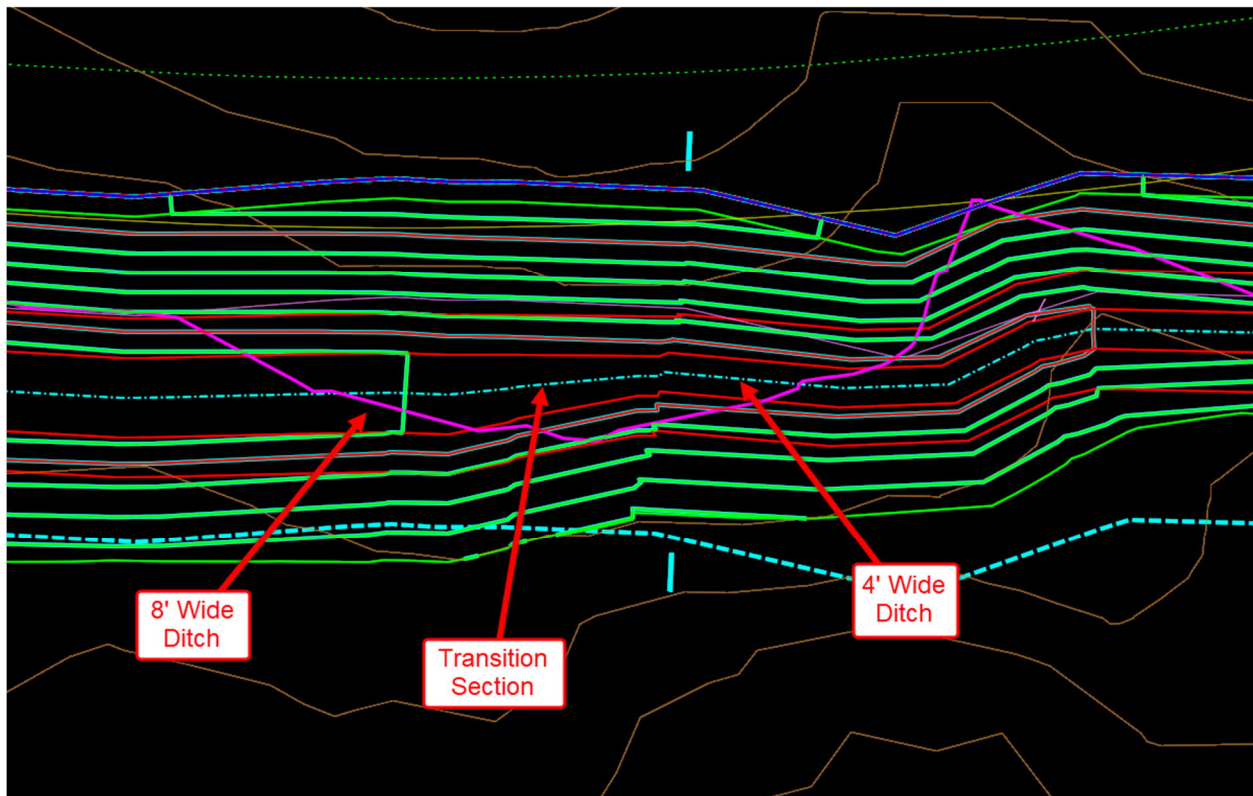
1. Select one of the corridor handles and from the flyout menu go to Corridor Creation Tools and from the drop-down menu select Create Parametric Constraint.

2. In the Create Parametric Constraint dialog (see next page), enter 640.00 for the Start location and 734.34 for the Stop location (the station of the end of the ditch corridor).

3. For the Constraint Label, select BottomWidth/2.

4. Change the Start Value and Stop Value for the parametric constraint to -4. The value is negative because the ditch is constructed from right to left, starting from roadway toe of slope. This will change the bottom width of the ditch from 4 feet to 8 feet. For ditches on the right side of the roadway, we would use positive values for BottomWidth/2.

Parameters	^
Lock To Start	
☑ Start	6+40.00
Lock To End	
☑ Stop	7+34.34
Constraint Label	BottomWidth ∨
Start Value	-4.0000
Stop Value	-4.0000

5. <D> in the view window to accept all dialog inputs. The ditch corridor will reprocess, and all views will update.

6. The next step is to add a section to transition the 4' wide bottom width to an 8' wide bottom width. Repeat the above process to add a new parametric constraint.

7. Enter 620.0 for the Start location and 640.0 for the Stop location.

8. Enter -2 for the Start Value and -4 for the Stop Value.

9. <D> in the view window to accept all dialog inputs to update the corridor.

10. This same process can be used to change any other dimension of the ditch.
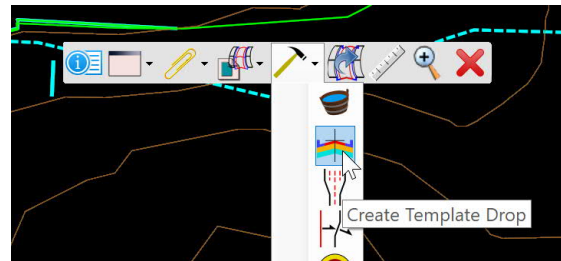
Determining Length of Transitions:

For creating parametric constraints for channel transitions, it is recommended to apply a 5:1 transition ratio. In the above example, the bottom width was increased from 4 to 8 feet, and the expansion occurs on one side of the channel. Therefore, the 4′ expansion is multiplied by 5 to obtain a transition length of 20 feet.

This guidance is based on the document "Design of Channel Transitions" by Victor M. Ponce of San Diego State University, which is based on previous work by Hinds (1928) and Chow (1959). See http://ponce.sdsu.edu/design_of_channel_transitions.html. This document recommends designing transitions using a deflection angle of 12.5 degrees, which roughly equates to a 4.5:1 ratio.

B. Adding Template Drops

In order to add, remove, or change the ditch lining it is necessary to revise the template being used for the corridor model for the station range where the change is needed. In the current example, Class B riprap has been used for the entire length of the ditch. It will be revised so that Class II riprap is used for the 8′ wide portion of the ditch beginning at 6+40.

1. Select one of the corridor handles and from the flyout menu go to Corridor Creation Tools and from the drop-down menu select Create Template Drop.

2. In the dialog, check the boxes for Start and End and enter 640.0 and 734.34 for the End.

3. Enter 5.0 for the Drop Interval.

4. From the drop-down list, select Lat_LT_Trap_Riprap_CL-II.

5. <D> in the view window to accept all dialog inputs to update the corridor.

Create Template Drop

| Parameters		^
Lock To Start		
☑ Start	6+40.00	
Lock To End		
☑ End	7+35.38	
☑ Drop Interval	2.0000	
Template	Drainage Ditches\Lateral Ditches\With Berm (DDE)\Left Side\Lat_LT_Trap_Riprap_CL-II	...

Graphic for Second
Template Drop

Graphic for First
Template Drop
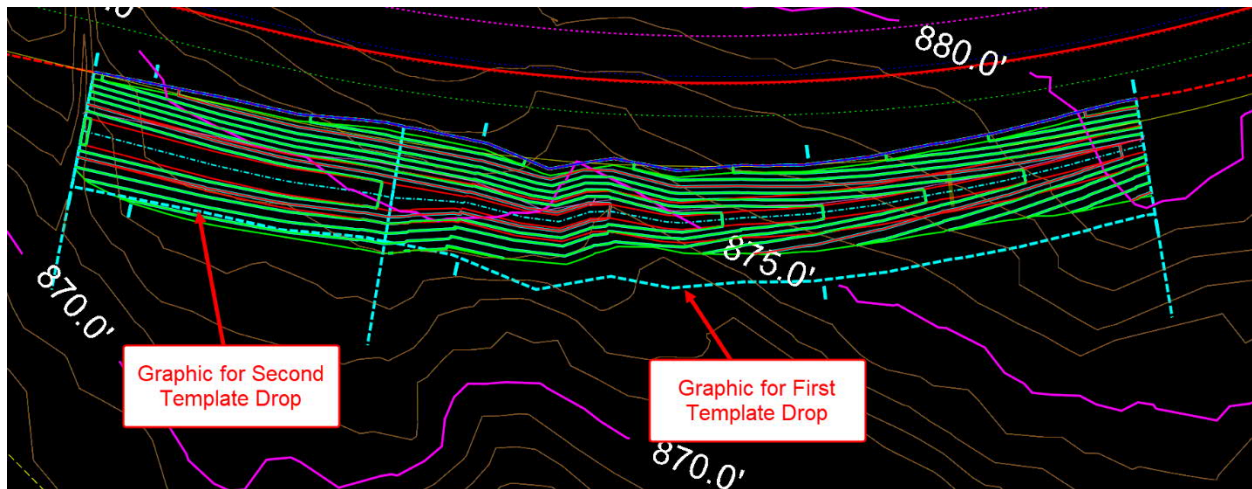
OpenRoads creates graphics in the plan view for the
template drops. If edits to a template drop are needed,
then select the template drop graphic and from the
flyout menu select Edit Template Drop. It is important
to remember that once a template has been dropped
into a corridor, it is completely separate from the
template library from which it came. Edits to the template drop do not change the
templates in the library.
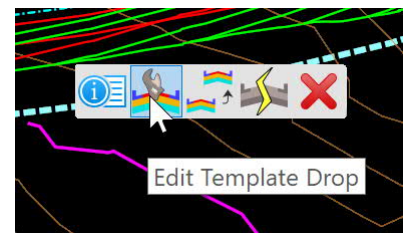
If you want the changes to be included in
the library, then first make the changes to
the library, then select the template drop
graphic and from the flyout menu select
Synchronize with Library. The changes in
the library will then be applied to the
template in the corridor.
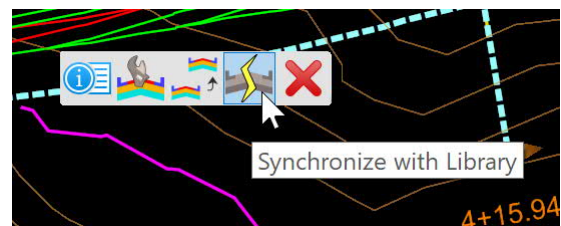
V. Construction Layout for Ditches

Station, offset, and elevation of ditch control points are needed for construction layout, and the stationing is typically referenced to the <u>roadway</u> baseline. The ditch corridor model provides a ditch centerline in the plan view and a profile of this centerline can be shown in a separate profile window. Use the following workflow to obtain roadway baseline station and offset, as well as ditch invert elevation, for the ditch reaches that were designed when setting the ditch corridor point controls. For this workflow, you will need to have two view windows open: one for the plan view, and one for the profile model for the ditch centerline.

1. Select the ditch center feature and from the flyout menu select Open Profile Model and select a view window if you don't already have the profile model for "DITCH_MIDDLE" set up.
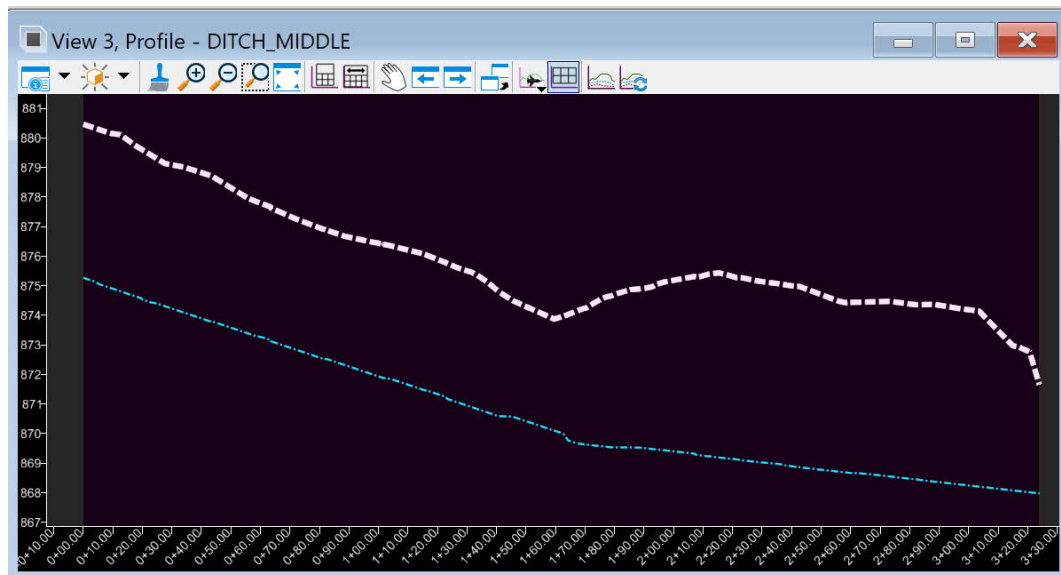

2. *Go to Home > Model Analysis and Reporting > Civil Analysis* and select Analyze Point. This is a very useful tool, and it is recommended that you include it on your Quick Access Toolbar.
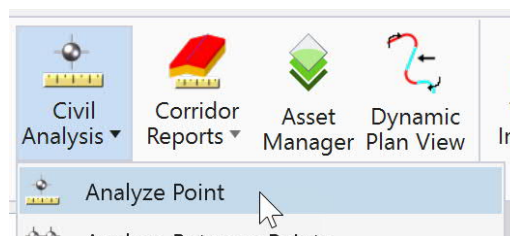
3. Select the roadway baseline feature. The Analyze Point tool will now provide feedback relative to the roadway baseline in both the plan and profile windows.

4. In the ditch profile window, snap to the start of the ditch centerline profile. Zoom in closely and be careful to snap to the very beginning of the profile.

5. In the dialog for the tool, the station, offset, and elevation ("Z on Snap") is shown for the selected point. The elevation reported by Analyze Point should match the elevation specified for the point control that was applied to the ditch corridor to set the ditch profile.
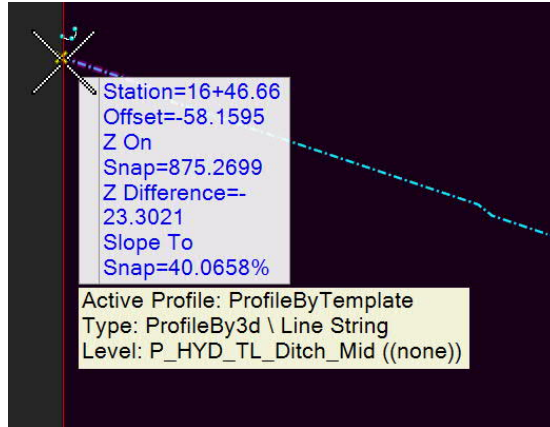
Continue this process for each vertical PI point to the end of the ditch to obtain all the station, offset, and invert elevation controls for the ditch. This information can now be used for plan and profile sheet annotation.

VI.   Ditch Quantities

Component Quantities

This tool reports the quantities of components based on a <u>corridor</u> model. Go to *Home > Model Analysis and Reporting > Corridor Reports > Component Quantities.* When prompted, simply select the corridor and a report is provided as shown below. In addition to the cut and fill volume quantities, surface area and volume quantities are provided for each of the template "components" that were used to create the corridor. Note that the surface area values for grass do <u>not</u> include the surface area covered by riprap. Also, surface area values are <u>not</u> provided for components that have thickness such as riprap. Unit costs can be entered into the report to generate an approximate cost estimate if desired.

Volumes are calculated using the Average End Area method, and accuracy is determined by the frequency of the template drop interval. For this reason, the results generated by the Component Quantities report are generally considered approximate, and appropriate for preliminary analysis.

Material	Surface Area	Volume	Units	Unit Cost	Total Cost/Materi
Cut Volume	0.0000	1142.3283	CuY	1.00	1142.33
Fill Volume	0.0000	2.3156	CuY	1.00	2.32
Mesh\HYD_Ditch\HYD_TC_Geotextile	5098.7281	0.0000	SqF	1.00	5098.73
Mesh\HYD_Ditch\HYD_TC_Grass_Berm	636.7914	0.0000	SqF	1.00	636.79
Mesh\HYD_Ditch\HYD_TC_Grass_Special_Ditch_DDE	5267.8918	0.0000	SqF	1.00	5267.89
Mesh\HYD_Ditch\HYD_TC_Riprap_CL-B	0.0000	109.9507	CuY	1.00	109.95
Mesh\HYD_Ditch\HYD_TC_Riprap_CL-II	0.0000	44.0533	CuY	1.00	44.05

Report   Total Estimated Cost: 12302.06

Clipping is not considered in quantities.   Corridor Name: LaterDitch-1

Element Component Quantities

This tool reports the quantities of components directly from the 3D elements generated by the corridor model. Go to *Home > Model Analysis and Reporting > Civil Analysis > Element Component Quantities*. When prompted, simply select the corridor and a report is provided.
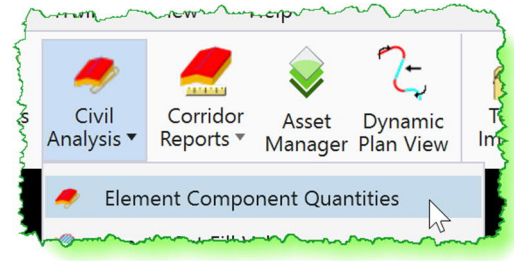
Element Component Quantities are more accurate than Component Quantities since they are not affected by template drops or the approximations inherent in the Average End Area method. This method also provides surface area quantities for riprap, unlike Component Quantities. However, the Element Component Quantities report only calculates the volumes of closed shapes (components) in the templates used for the corridor. For this reason, earthwork cut and fill volumes are <u>not</u> provided. Also, quantities reported by station are not available, as they are with the Component Quantities tool. Therefore, it is recommended to use Component Quantities to obtain the cut and fill volumes, and Element Component Quantities for the other quantities.

Material	Surface Area	Volume	Units	Unit Cost	Total Cost/Materi
Mesh\HYD_Ditch\HYD_TC_Grass_Berm	636.2239	0	SqF	1.00	636.22
Mesh\HYD_Ditch\HYD_TC_Grass_Special_Ditch_D...	5309.1565	0	SqF	1.00	5309.16
Mesh\HYD_Ditch\HYD_TC_Geotextile	5170.0113	0	SqF	1.00	5170.01
Mesh\HYD_Ditch\HYD_TC_Riprap_CL-B	0	110.5913	CuY	1.00	110.59
Mesh\HYD_Ditch\HYD_TC_Riprap_CL-B	3234.4642	0	SqF	1.00	3234.46
Mesh\HYD_Ditch\HYD_TC_Riprap_CL-II	0	45.3186	CuY	1.00	45.32
Mesh\HYD_Ditch\HYD_TC_Riprap_CL-II	1312.2850	0	SqF	1.00	1312.29

Report

Total Estimated Cost: 15818.05

Elements Name: LaterDitch-1

Quantities from 3D Mesh Elements

OpenRoads has a powerful set of tools that can create and utilize 3D mesh elements generated from corridor models using the Create Cut Fill Volumes tool located at *Home > Model Analysis and Reporting > Civil Analysis*. This tool creates 3D solids, or meshes, in the 3D model of the DGN file. These are then used to compute accurate volume quantities for cut and fill, as well as excavation of unsuitable materials, substrata, and subgrade surfaces. This is a complex topic beyond the scope of this Manual. More information is available through the Bentley Learn Server at https://learn.bentley.com/app/Public/ViewLearningPathWithMasterCourseExpanded?lpId=113539&mcId=103116